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SOCIAL CLASSES OF CANADA GEESE IN WINTER

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SOCIAL CLASSES OF CANADA GEESE IN WINTER[1]

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Abstract: Seventy-seven Canada geese (*Branta canadensis interior*) were marked with transmitters, nasal disks, and dye to allow recording of their locations and observation of their behavior during winter. Marked geese included all or parts of 10 families, 2 pairs, and 33 yearlings. Behavior was not substantially affected by marking. Families remained intact all winter and reassembled if separation occurred. Of 20 yearlings whose social status was identified, 19 were singles, 4 were members of families, 2 were a sibling pair, and 1 was paired. Two single yearlings were closely associated in locations and movements. Bonds among adult and immature survivors in families disrupted by mortality did not appear to be affected. Yearlings in families were probably more loosely attached to the parents than were immatures.

Our knowledge of the gregarious social life of Canada geese has been a mixture of facts and folklore, especially with regard to yearlings and family behavior and unity. Data on daily winter activities of the same individuals of different social status have been lacking. The study of daily sociobehavioral interrelationships and movements of the same individuals of many wild species was made possible by the development of radio-telemetry (Slater 1963, 1965). The purpose of this paper is to report results from a study of the social structure of Canada geese during winter using radio-telemetry.

This study was a cooperative project with the U. S. Bureau of Sport Fisheries and Wildlife and the Illinois Department of Conservation. L. A. Mehrhoff, R. C. Personius, and the rest of the staff at Crab Orchard National Wildlife Refuge, D. W. Warner, W. H. Marshall, B. J. Vents, and W. W. Cochran are gratefully acknowledged for their helpful assistance and advice. Transmitters and receivers used were based on then unpublished designs of equipment developed at the Museum of Natural History, University of Minnesota. H. C. Hanson served as consultant to the project and greatly enhanced my understanding of Canada geese. W. E. Crews assisted in all phases of the field work and W. D. Klimstra served as principal investigator. His efforts, encouragement, and advice are gratefully acknowledged.

METHODS AND MATERIALS

Location of Study

As many as 200,000 Canada geese spend a large part of the winter in southern Illinois in and around three major refuges. They are almost all of the subspecies *interior* (Hanson and Smith 1950, and Hanson, personal communication). The study was carried out primarily at Crab Orchard National Wildlife Refuge in Williamson and Jackson counties from late September to mid March, 1963–64 and 1964–65. Crab Orchard Lake is approximately 7,000 acres and the refuge area encompasses 44,000 acres. One-half of the area is open to public use, including hunting. The geese roosted mainly at the lake and fed primarily in corn, soybean, and wheat fields in the inviolate one-half of the refuge.

Some winter observations of Canada goose behavior were made at Horseshoe Lake

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(Alexander County) and Union County Refuges. These refuges, which are in the fertile, alluvial flood plain of the Mississippi River, are much smaller than Crab Orchard (approximately 7,000 acres each) but attract more geese. Horseshoe Lake is described by Hanson and Smith (1950).

Capture and Identification of Experimental Geese

The objectives of this study required that complete family units be trapped and marked. Cannon-net trapping (Dill and Thornsberry 1950) usually captures large numbers of geese and related birds cannot be identified. Some families or small flocks (less than 20), however, spent the midday roosting at one of several small (0.1–0.5 acre) ponds on the refuge instead of returning to Crab Orchard Lake. Cannon-nets were placed along the shoreline of these ponds. Careful observation of small groups of geese allowed identification of families. A gander, often accompanied by part or all of his family, would chase other geese from a loafing or feeding area, or succumb to a more dominant group. Occasionally, this chasing behavior, especially if over a small amount of bait (corn) in front of the cannon-net, allowed just one family to be caught.

Yearling geese and some other individuals marked for this study were taken from large trap samples regularly obtained by the refuge for their banding program.

Age and sex of trapped geese were determined from criteria presented by Hanson (1962). Age classifications utilized are as follows: immature—from hatching until the return to nesting areas the following spring; yearling—from the time of return to nesting areas for their second summer of life until their return to nesting areas the following spring; adult—from the beginning of the third summer of life and older.

Experimental Markings and Transmitters

Forty geese in 1963–61 and 37 in 1964–65 were fitted with transmitters similar to that described by Cochran et al. (1963) and colored ¾-inch nasal disks (Lindmeier and Johnson 1958, Bartonek and Dane 1964). White areas of the abdomen and cheek were colored with dye (Croceín Scarlet, Croceín Orange, Auramine, Fast Green) (Boyd 1952, Kozlik et al. 1959). Dye was applied a second time after the first application had dried thoroughly. Geese with transmitters were held in confinement for 1 or 2 days after capture to allow the dye to dry and the birds to rearrange their plumage.

Fitting a transmitter to a goose required manipulation of the larger loop over the body from the posterior to approximately its final position on the breast. The head and neck were then pulled through the smaller neck-loop. Transmitter size and placement and nasal disks are illustrated in Figs. 1 and 2.

Total weight of transmitters (including harness) varied from 50–90 g depending upon the size and number of batteries. In general, the transmitters were designed for a theoretical operating life of 120–150 days. The frequency range was 53.00–53.20 mc with transmitters spaced at 5 kc intervals. Fifteen radios were continuous wave and 62 operated as pulsing transmitters averaging 200–300 beats per minute. The combination of 5 kc spacing and a distinctive pulse rate and tone ensured positive identification of an individual signal.

Techniques of Radio-Tracking

Directional antennae were used to determine the locations of radio-marked geese. Four permanent, rotating 8-element beam antennae on 30 ft masts were placed at strategic locations on the refuge. Three, 4-

Fig. 1. Design and size of transmitter used on Canada geese (note nasal dam).

Fig. 2. Canada goose with transmitter in place.

or 5-element beam antennae with 10-ft collapsible masts were kept at convenient observation posts near the lake and were moved to different sites as needed. Two vehicles were equipped with a vertically oriented rotating loop antenna similar to that used by Verts (1963). A vehicle antenna was rotated by hand via a pulley system with a pointer on the handle indicating antenna orientation. The base of the loop was fixed to a hinged plate which allowed lowering the antenna when traveling.

Design and specifications of the receiver utilized with both the vehicle loop and beam antennae are unpublished data of W. W. Cochran. Also available was one Model D-11 portable receiver with loop antenna (Cochran and Nelson 1963) for field use away from vehicles or beam antennae.

Study Procedure

Data recorded from transmitter-marked geese were as follows: lake location prior to flight in the morning, time of flight, location in fields, time of flight to lake or changes of feeding areas, midday roost locations, time of afternoon flights and field locations, and time of flight to lake in the evening. During periods of concentrated flight movements the investigators were stationed at locations where the greatest number of marked geese could be observed and/or radio-tracked. Two-way radio communication enhanced efficient utilization of time. We could determine the beginning or ending of a flight by radio-marked geese by continuous scanning of the frequency range. The moment these birds flew, easily detected increases in auditory signal strength occurred, especially as the geese rose above treetop level. The reverse occurred during descent and landing. Triangulation was rarely needed to establish locations of the radio-marked geese as the distribution of geese on water and land was usually observable.

After radio-marked geese were located, attempts were made, usually with a spotting scope, to observe their behavior without disturbing them.

RESULTS

Transmitter Dependability

Transmitters were placed on all or parts of 10 family units, 2 pairs, and 35 yearlings. During 1963–64, only 18 of 40 transmitters operated sufficiently to provide continuous

data. Since 15 of the 22 unsatisfactory radios were on family members, and in every family at least one transmitter operated well, few data were lost as family members proved to rarely be separated. Transmitters in 1964–65 were markedly improved and 30 of 37 performed satisfactorily.

A meaningful average transmitter-operating-life cannot be calculated as 19 geese departed from Crab Orchard during winter or in spring migration with functioning transmitters. Radio and observational contact were maintained with 9 families and 2 pairs (43 geese) from 12–106 days (average—60 days) and with 23 yearlings or other single geese from 12–113 days (average—44 days). Transmitters that failed before 10 days of operation or were on geese that left within 10 days of their release are not included in the above calculations.

Transmitters came off 3 geese, all within 9 days after release. Two geese that had transmitters attached in autumn, 1964, were shot by hunters in autumn, 1965, and both individuals still carried their transmitters. Of at least 7 different individuals marked in 1963–64 and observed in 1964–65 (identifiable by nasal disks) one definitely had retained its transmitter. It could not be determined whether or not the other 6 were still radio-tagged as transmitters were usually concealed in breast feathers.

Range and Accuracy of Direction-Finding

Effective ranges of transmitters from marked geese on land or water varied as follows: (a) to an 8-element beam, 1–3½ miles, average approximately 1¾ miles; (b) to a 4- or 5-element beam, average approximately 1–1¼ miles; (c) to a vehicle-loop, ½–1½ miles, average approximately ¾ mile. It was not determined how far a signal from a flying goose could be received but one presumed straight line flight of 18 minutes was recorded from an 8-element beam antenna. Assuming a 30–35 mph flight speed, this indicated that the signal was received from 9 or 10 miles away.

Table 1. Numbers and hours of observations of radio- and color-marked Canada geese.

Social Status	Number of Observations	Hours of Observation
Single immatures	26	19
Single yearlings	101	61
Single adults	33	22
Pairs	34	33
Families of 3	55	50
Families of 4	35	44
Families of 5	73	72
Family of 6	4	3
Totals	307	307

Accuracy of direction indicated by permanent beam antennae was not determined as these antennae were used to find only general direction. Vehicle loop antennae and the smaller beams were used for recording exact locations. Comparison of locations indicated to actual locations showed a radio-fix accuracy of approximately 2° to 4° at ½ mile from the radio source.

Numbers of Observations of Experimental Geese

The finding and continuous observation of the experimental geese was difficult and time consuming. Since minimum disturbance was essential it was frequently not possible to approach close enough to observe the marked geese. Few attempts were made to regularly locate and observe the experimental geese when they fed beyond refuge boundaries.

The numbers and hours of observations of marked geese are presented in Table 1. These data represent only those times when an individual or group was watched nearly continuously for a recorded period.

Effects of Marking Geese

No noticeable lasting effects of dye and nasal disks on behavior were observed. Marked families in which one or more members had escaped at the time of trapping, regrouped after release, and no abnormal effects were observed with either marked or unmarked family members or with other geese.

During the first 1 to 3 days after release most marked geese spent long periods of time preening, especially around the transmitter. Some geese bit and pulled at their transmitters, but none continued vigorous pecking or pulling after the first day or two. Geese bearing transmitters continued to do more breast preening than did unmarked geese. No other behavioral difference was noted. They flew well and engaged in all the daily activities of the flock. Subsequent examination of geese that had worn transmitters showed no signs of skin abrasion or other irritation except that some feathers were missing on the breast where the transmitter was located.

Efficiency of Nasal Disks and Dye

Nasal disks were known to come off two geese during the study: one after 61 days and the other after 76 days. For retention and ease of observation, nasal disks are inferior to some other marking methods (Sherwood 1966*a*). However, the combination of disks and dye on the abdomen proved satisfactory for this study. Experimental geese were almost always first noticed because of the colored abdomen, which also made it easy to follow the birds' movements. Nasal disk color was used to signify age-sex class. Dye was not retained well on the cheek patch because this part of the head was used in preening. In most cases, enough dye for positive identification remained on the abdomen for about 2 months.

Reassembly of Families After Capture and Release

The word "family" is used here to indicate any association of two or more geese resulting from a pair bond or parent-progeny-sibling relationships. Families of three or more represent an adult pair with their offspring, unless otherwise noted, or surviving members of such an association. Not all members of all families in this study were trapped and marked (Table 2). In these instances, however, it was possible to determine subsequently the age of the unmarked geese and the sex of unmarked adults by comparison of their plumage, size, and behavior with the known age-sex individuals of the group. Since the history of the marked geese before trapping was unknown, it is not possible to state unequivocally that the young of these families were in fact hatched and raised by the adults with them at the time of trapping. However, the result was the same, that is, the study birds behaved as a family unit in all their daily winter activities. Family-related geese are bound together and recognizable by the mutual performance of the *Triumph Ceremony* (head and neck waving with raucous honking—Fischer 1965; Klopman 1961; Lorenz 1939, 1966; Raveling 1967).

All captured members of a family unit were released at the same time and place, some releases at the point of capture and some up to 2 miles away from the capture site. Even though released together, immediate temporary separation of family members almost always occurred (Table 2) because adult geese, particularly ganders, were more powerful fliers and quickly outdistanced immatures. Some marked geese could not (or did not) fly at the time of release, probably because of strained muscles and plumage derangement.

Permanent separation of family members

Table 2. Length of time for pairs and families of Canada geese to be reunited and to resume normal daily activities after being captured and released.

GROUP	STATUS JUST AFTER RELEASE	APPROXIMATE INTERVAL BETWEEN RELEASE AND COMPLETE REUNIFICATION	APPROXIMATE INTERVAL BETWEEN RELEASE AND RESUMPTION OF NORMAL DAILY ACTIVITIES AS AN INTACT UNIT
Sibling pair[a] (Yearling males)[b]	Together	–	½ day
Mated pair[a] (Gander not captured)	Separated	Within 4 hours	½ day
Family of 3 (Adult male and 2 immature males)	Separated (2 & 1)	1 day	1½ days
Family of 3	Separated (2 & 1)	1 day	3 days
Family of 3	Separated (2 & 1)	2 days	3 days
Family of 4 (Only adult male and one immature captured)	Separated	2 days	2 days
Family of 4[a] (Only adult female captured)	Separated	?	3 days
Family of 5 (One immature not captured)	Separated	2½ days	4½ days
Family of 5 (Adult male not captured)	Separated (3, 1 & 1)	7½ days	7½ days
Family of 5	Separated (3, 1 & 1)	2 days	3½ dys
Family of 5 (One immature not captured)	Separated (4 & 1)	1 day	5 days
Family of 6	Together (Separated somewhat in flight at release but reunited within minutes after landing)	–	4½ days

[a] Size and relationship of group determined by observations after release and reunification—all other family sizes reported here were known at the time of trapping and subsequently confirmed by numerous observations after release and reunification.

[b] See text, p. 311.

did not occur (Table 2). Because families habitually utilized only one small portion of the available lake shoreline area reunification was facilitated (Raveling 1967:116–121). Released geese usually flew or swam a variable distance and joined nearby geese where they stopped and preened. Within 2 days after release, the separated family members returned to an area which subsequently proved to be their usual lake-roost site and were reunited as an intact family but did not resume regular, daily flight movements as a unit until approximately 4 days after release (Table 2). In contrast, single geese (3 adults and 19 yearlings) resumed normal flight activity in 2 days. Often the geese taking the longest time to resume normal patterns of activity would hold a wing slightly out of the "socket" of flank feathers, presumably because of muscle strain. Immature geese were usually affected more than adults.

Integrity of Families During Winter

Telemetry proved that criteria for identification of families captured for this study were correct. Results demonstrated that individual members of families were almost always in close physical association (Table 3). The 96 percent estimate for the amount of time families were together as a unit is minimal for two reasons: (a) extra effort was made to observe and record activities of family members when it was known they were separated; (b) Table 3 does not include hundreds of records when most transmitters in a family were working and signals were all coming from the same location.

Data from four marked families are not

Table 3. Observations of the cohesiveness of marked families of Canada geese during winter.[a]

Family Size	Number of Observations after Complete Reunification of Family	Number of Observations when Family was Together	Date of Last Observation
Three	9	9 (100%)	17 Jan.
Three	31	50 (88%)	10 Mar.
Five (One immature not captured)	7	7 (100%)	20 Nov.
Five (One immature not captured)	30	29 (97%)	17 Feb.
Five	32	32 (100%)	13 Mar.
Six	4	4 (100%)	22 Dec.
then 4[b]	29	28 (97%)	22 Jan.
then 3[c]	11	11 (100%)	22 Feb.
Totals	150	150 (90%)	

[a] Does not include incomplete data from 4 other marked families—see text, p. 310.
[b] Female killed, yearling separated permanently—does not include observations of one immature temporarily separated after female was killed.
[c] Adult male collected by investigator leaving only three immatures.

included in Table 3. In two of these families, two or more members were unmarked, and it was not always certain that these families were intact when observed. When only one family member was unmarked it was almost always possible to state that the unmarked individual was or was not with the family, and data from these two families are included in Table 3. Transmitter failure and few observations prevented inclusion in Table 3 of data from a family of five. The fourth family not included in Table 3 was a unit of two immature males and a gander in which both young died within 18 days of their capture and release.

Through the period of observation of each family of this study, continued unity was the rule. During spring migration in Wisconsin unmarked family units were identified during mid- to late April. Some families containing young were also still in evidence after arrival at nesting areas in the Kinoje River area of the James Bay lowlands in Ontario (Raveling and Lumsden, unpublished data).

Effects in "Broken" Families.—Several observations were made of a marked family before and after mortality occurred. Radio-tracking and observations of a family of six (pair, three immatures, and one yearling) that stayed together at the time of release (Table 2) demonstrated that all six were continuously together for 14 days after release except that the gander and immatures resumed feeding flights before the adult female and yearling. Later the female was believed to have been killed by a hunter. Geese were observed to be "milling" in all directions over the field where she was presumed to have been killed. After returning to Crab Orchard Lake the yearling and one immature were separated (in two different locations) from the other two immatures and the gander (which were together). The lake was freezing, and these remaining family members were forced to abandon their regularly used roost site for one of the few remaining open water areas. The separated immature rejoined the gander and other two immatures after 8 days. The yearling remained separated for 10 days, did not fly out to feed, and then disappeared from Crab Orchard. The gander and three immatures were then almost continuously together for 22 days (Table 2) before I collected the gander. The three siblings remained continuously together after the death of their gander until the time they

were last observed in late February (Table 2). The yearling reappeared at Crab Orchard on the day the gander was collected and stayed for at least 12 days but he did not rejoin the three immatures.

Status of Yearlings

Transmitters were placed on 35 yearling geese; transmitter performance and observations were considered sufficient for determination of the status of 26 (15 males and 11 females).

Yearlings in Families.—Four of the 26 yearlings (15 percent) were part of a family unit for at least part of the winter. Criteria used to determine if yearlings (or any other individuals) were members of a pair or family unit were: unity in preflight and flight behavior; acceptance or tolerance by other geese (especially the gander) in the group; joining a group in aggressive display; entrance into a triumph ceremony with a group; consistent movements in swimming and walking which often revealed families acting as a unit, especially when movements were initiated by a gander (usually always identifiable by their size and behavior).

One of these family-member yearlings was part of a completely radio- and color-marked family of six described above from which he became permanently separated. The other three family-member yearlings were obtained from large catches of geese and the remainder of the families they were associated with were not color-marked. However, one family with which one yearling was always observed was in part identifiable. The gander had a particularly striking ring of white feathers at the base of the black neck and two other members were leg-banded.

Yearlings in Sibling Pairs.—Martin (1964) and Sherwood (1966*b*) demonstrated that some yearling siblings remain together throughout the summer and apparently the second winter of life. One such association was encountered during my study. Four yearling males were identified in a catch of 22 geese on October 24, 1964. Two of these were side by side under the net and at the time they were removed their remarkable physical similarity was noted. While such criteria are not conclusive for determining broodmates, considerable individual variations or conformities among individuals are noticeable. The transmitter on one of these individuals failed after 4 days, but these two geese were observed virtually side by side on 13 occasions until January 30. They acted as related geese, being synchronized in flight movements, occasionally in attacking, and often in avoiding other attacking geese. Only once was one observed when the other was not also visible in the immediate vicinity. I concluded that these two yearlings represented siblings that had remained together.

Groups of Unrelated Yearlings.—Some apparently unrelated yearlings in winter exhibited a degree of close association in roosting areas, feed-field locations, and in synchronization of flight. Two yearling males trapped on October 25, 1964 were radio-tracked almost continuously to January 9, 1965. These two birds were in the near vicinity of one another in roost and feed-field locations on approximately 75 percent of the radio locations and flew together in the same flock over 50 percent of the time (Table 4). They were observed together in the same general vicinity nine times but they were separated by 100 yards or more on 12 observations. During all observations (over 20 hr) neither goose behaved in any manner to indicate that they were paired to each other or to any other goose, or were part of a family.

This association of what appeared to be

Table 4. Degree of close association between two unrelated yearling males as demonstrated by locations and times of flight recorded with radio-telemetry between 27 October, 1964–9 January, 1965.

Activity and Number of Locations[a]	Percent of Locations or Flight Times When Both Yearlings Were Together[b]
Night roost location (determined prior to any morning flight activity) N = 69	78
Time of flight from lake in the morning N = 70	77
Morning feed-field location N = 60	83
Time of flight from morning feed-field to midday roost location N = 26	50
Midday roost location N = 53	77
Time of flight from midday roost location to afternoon feed-field location N = 19	58
Afternoon feed-field location N = 53	72
Time of flight from afternoon feed-field location to night roost location N = 50	68

[a] Data in this table include only those records in which the activity of both geese was known.

[b] Together means that a detectable difference in radio location was not determined—or they were actually observed together (i.e., within 20 or 30 yards).

unrelated geese was not expected. I radio-marked 6 and 17 yearlings obtained from catches made at the same trap-site on December 16, 1964, and January 11, 1965, respectively, to determine whether or not such behavior was common. If such associations were common, then some of these 23 yearlings should have exhibited a pattern similar to the 2 birds described above. Twenty-two of these 23 yearlings were subsequently observed at least once, and there was no indication that any two were associated in a "loose" group. One transmitter came off and three failed within 4 days; however, 3 of these geese were subsequently observed. Three yearlings departed from Crab Orchard within 15 days, all at different times. The remaining 16 individuals were radio-tracked an average of 44 days (range 15–72 days). None showed any consistency with another in roosting, feeding, or flying together.

Yearlings as Mated Pairs.—Of the 26 yearlings whose social status was determined, only one, a female, was paired. Her mate was not marked, but the female was observed on seven occasions between November 29, 1964, and February 17, 1965, and every time she was a member of a pair. Her mate was considered an adult male and not a sibling because of his size and behavior.

Single Yearlings.—Nineteen of the 26 yearlings (73 percent) identified as to social status were considered to be single geese throughout the period in which they were radio-tracked and observed. Thirteen of these 19 were last observed in February or March, the beginning of spring migration. I conclude that the majority of yearlings were singles in winter and began spring migration as such. Criteria used for identifying singles were essentially the lack of behavioral patterns observed to typify pair or family status. Singles were generally unalert, avoiding, and submissive geese; lacked synchronization with others in preflight behavior, walking, swimming, and agonistic situations; did not enter the triumph ceremony with other geese, and exhibited a scattered pattern of roost locations (Raveling 1967).

Status of Single Adults and Immatures in Winter

After the two immatures of one family of three died, the remaining gander was observed 6 times up to February 9 always alone. Two other adult males, radio-tracked for relatively short periods in early winter, were singles; one was observed 14 times

from October 10 to November 24 and the other was observed 3 times from October 23 to December 6. One adult female with a transmitter, observed on 5 occasions between January 10 and February 6, was always a single. One immature male Canada goose was followed from January 10 to March 2 and on each of 12 observations was a single.

DISCUSSION

Techniques

Normal behavior of some birds is disrupted by color-marking (Coforth and Baskett 1965) and Aldrich and Steenis (1955) cautioned about possible effects on Canada geese. Lensink (1968) provided indications that neckbands may inhibit reproduction of black brant (*Branta bernicla*) but did not cause any other type of aberrant behavior. This study confirms numerous reports that dyeing, nasal disks, and other types of color-marking have no noticeable, lasting effects on the behavior and social relationships of geese under investigation here (Boyd 1952, Hein 1955, Craighead and Stockard 1956, Craighead and Craighead 1957, Marquardt 1962, Ballou and Martin 1964, Miller and Dzubin 1965, Sherwood 1966*a*).

Families

Many goose banders have expressed concern about whether or not trapping and the usual method of releasing geese one at a time after banding might cause breakup of family units. For example, Scott and Fisher (1953:20) thought family ties would be broken by such procedures and therefore all captured geese were held and released simultaneously.

Separation of family members due to trapping is inevitable. In large cannon-net catches, not all family members would be caught by the net-throw (Raveling 1966). When intact or partial family units were released together in this study, separation occurred but was never permanent. The Canada geese used in this study were subjected to more handling than geese trapped for banding purposes; however, great differences in the ability or inclination to fly strongly after release are almost always noted in regular banding operations. Others have observed regrouping of families of white-fronted geese (*Anser albifrons*) (Boyd 1952, Miller and Dzubin 1965) and Canada geese (Hanson 1953) after capture and release.

Miner (1923:122) reported that adult Canada geese occasionally left their young but not for more than an hour, and Elder and Elder (1949) suggested this habit may have contributed to the abundance of pairs observed in local movements at Horseshoe Lake. Typical family behavior I observed, however, was almost continual unity. Separation of pairs and families (triumph ceremony partners) creates an appetitive searching behavior (Fischer 1965:257). It is concluded that separation of pairs and families during winter is rare.

Since 1900 most authors commenting on wintering flocks of geese have noted what appeared to be family groups (see reviews by Elder and Elder 1949, Balham 1954). Boyd (1953:88) noted the uncritical acceptance of the "fact" of family unity but he, as nearly all goose researchers, utilized the concept of family cohesiveness throughout the winter season. Recent studies with marked Canada geese demonstrated that families departing in autumn often returned the following spring still intact as units (Martin 1964:9–10, Sherwood 1966*b*:100–122) and the present study demonstrated that family unity in daily activity throughout the winter is maintained.

There remains the question of whether or not immature geese of a family actually represent progeny of the adults with which they are associated. Numerous studies have established that brood-mixing or "adoption" of goslings can be common for *B. c. moffitti* in western United States (Williams and Marshall 1938, Miller and Collins 1953, Geis 1956, Steel et al. 1957, Hanson and Browning 1959, Martin 1964:24–25) and for *B. c. maxima* (see Hanson 1965 for subspecies identification) in northcentral United States (Kossack 1950, Collias and Jahn 1959, Brakhage 1965, Sherwood 1966*b*:124–132). The usual occurrence when brood-mixing is common is the formation of some "families" or "creches" of a size much larger than average clutch size. Some studies of *moffitti* or *maxima* have not revealed brood-mixing (Kebbe 1955, Craighead and Craighead 1949, Balham 1954:174, Klopman 1958). Hanson (1965:152–154) concluded that there is no evidence for suggesting that brood-mixing occurs in *interior* and that the families represent parents with their progeny. No evidence was obtained in this study to indicate anything but expected family sizes and relationships.

The bonds among surviving siblings or with a surviving parent did not appear affected by the loss of one or more family members. Balham (1954:61), Martin (1964: 10), and Sherwood (1966*b*:100–122) found that remnants of families broken by hunting migrated north in spring together. Observation of the yearling which separated from his family after the female was killed suggests a more loose relationship of yearlings that have rejoined their parents than exists among immatures (see also Boyd 1955, Martin 1964:28). Before breakup of this family I noted that this yearling, while definitely an integral part of the family, seemed to be less dependent on or influenced by movements of the gander than were the immatures.

Yearlings

Some workers have been reluctant to believe that yearling geese may rejoin their parents with a new brood and that this association could extend into or through the winter. Lynch and Singleton (1964) observed among *Anser* many groups indicating family behavior but which contained three or more adults rather than the expected pair. They speculated that such groupings may represent polygamy. Boyd (1953) observed three-adult families of white-fronted geese and suggested (Boyd 1954) such groups might represent bigamy, temporary associations or, following the suggestion of Konrad Lorenz, yearlings readmitted to the family. Subsequently, Boyd (1955, 1957, 1959) surmised that yearlings rejoined their parents for a second winter. Earlier, Heinroth (1911:621) noted the likelihood of greylag (*Anser anser*) yearlings rejoining their parents, but he did not know to what extent this might occur. There are numerous observations of individually marked Canada geese demonstrating that some yearlings rejoin their parents, occasionally before but usually after the summer molt (Balham 1954:153, Martin 1964: 28, Sherwood 1966*b*:100–121).

Based on photographs of *B. c. interior* on their nesting grounds, Hanson (1965:155) suggested that some yearlings rejoined families but that most do not. The percentage of yearlings behaving in this manner is not known but probably would vary from year to year depending on nesting success of adults, size of the yearling cohort, prevalence of pair formation among yearlings, and other factors. Results of this study and of Sherwood (1966*b*:100–121) indicate that rejoining of families by yearlings may be relatively common.

Lynch and Singleton (1964:125) noted bands of yearling blue and snow geese (*Anser caerulescens caerulescens*) (the method of age identification is not clear), but dismissed the possibility that these groups represented siblings. They did note, however, that to consider yearling groups as casual aggregations of unrelated birds would be speculative.

I suggest that the presence of yearlings in families, sibling pairs, or groups may be even more common than indicated in this study. Thirty-one of the 35 yearlings of this study were marked in 1964–65; thus, they were part of a cohort representing the results of the poorest reproduction in years for this population as judged by age ratios of trap samples, hunter-kill, breeding-ground reconnaissance, and total numbers of the flock (Harold C. Hanson, personal communication). Therefore, it is logical that, following such a poor hatch or survival of goslings, the numbers of sibling pairs or larger groups surviving into their yearling winter may have been less than usual.

Polygamy (almost always one male and two females) and unisexual pairs (almost always two males) do contribute to three-adult families or yearling pairs and groups in some cases (Heinroth 1911:601, 622; Lorenz 1959:218, 1966:195–199; Fischer 1965:270; Kossack 1950; Balham 1954:74; Collias and Jahn 1959; Brakhage 1965). All these occurrences, however, were in captive or semi-tame, small flocks. Heinroth (1911:622) noted that polygamy or promiscuous mating could occur until the triumph ceremony became established between a pair. Lorenz (1959:218, 1966:195–204) discussed in detail the formation of unisexual pairs and other "abnormal" combinations as dependent upon changes in pair formation behavior caused by familiarity of geese with one another in small or captive flocks which would not occur in large wild populations. I believe the triumph ceremony pair of yearling males of this study and the three-adult families and yearling associations reported by others represent familial associations.

There has been a general opinion that yearling geese tend to associate in groups of family size or larger (Lynch and Singleton 1964). Lebret (1950) thought yearling white-fronts tended to congregate in groups, and Boyd (1950) generalized that family parties and adults without young tended to form more or less distinct aggregates within a flock. It is not clear whether they believed these groups to be regular associations governed by the birds' social relations with one another or merely aggregations resulting from proximate factors not requiring regularity or "social bonds."

Lynch and Singleton (1964) noted yearling groups averaged two birds per group. When these and larger groups represent siblings, as discussed above, group cohesion and activity resemble that of families. Evidence from this study reveals that single presumably unrelated yearlings may at times be closely associated in movements and use of specific areas. But the most common situation with yearlings was single status, and movement and use patterns more varied than those of families (Raveling 1967). Further, it is possible that the yearlings of this study which were closely associated but did not behave as obviously related geese were in fact siblings that were no longer held intimately together with a triumph ceremony. Lorenz (1966:191) noted that bonds between former triumph ceremony partners are never really completely severed. Therefore, personal recognition may serve to keep sibling yearlings together even though they are not bound closely by the triumph ceremony.

An additional factor which could cause seemingly unrelated yearlings to be associated through the winter is that yearlings beginning the process of pair formation the previous summer likely remain loosely together throughout their yearling winter, but are not identifiable as mated pairs by their behavior. Based on very indirect evidence it has long been suggested that Canada geese pair during winter (Bent 1925, Delacour and Mayr 1945:8–10, Hanson 1953, Naylor 1953). Balham (1954:62) appeared to concur in this conclusion but he noted that some pairing occurred among yearlings in summer. Many studies have now demonstrated that sexual behavior, including copulation, is common among yearling Canada geese during the nesting season, either as true pairs or promiscuously (Balham 1954:32–77, Geis 1956, Collias and Jahn 1959, Klopman 1962, Martin 1964:30–33, Craighead and Stockstad 1964, Wood 1965, Brakhage 1965, Sherwood 1966*b*:133–134).

Since pair-formation behavior is common among yearlings during summer it was unexpected that only one yearling observed during this study was paired. This is because initial yearling pairs are short-term associations which are dissipated by the onset of molt (Martin 1964:33, Sherwood 1966*b*:133–134). Brakhage (Personal communication) observed that marked individuals of yearling pairs in summer *did not* associate through the following winter as true pairs, but the *same* two individuals often rejoined as mated pairs in a lasting association in late winter and early spring at the onset of their 2-year-old season. Lorenz (1966:193–194) noted that when "serious" courting of 2-year-old greylags begins, males often return to their "love" of the previous year.

No pair formation occurred among the marked yearlings or single adults of this study, but transmitters had usually failed by February or March and few observations were made just prior to spring migration. Some pair formation was observed to occur among unmarked geese.

A factor that could have influenced the status of yearlings observed in this study is hunting. Nineteen of the 26 yearlings were trapped during or after the hunting season. Effects of possible breakup of yearling relationships due to hunting in Wisconsin and other areas prior to arrival at their terminal wintering area in southern Illinois are not known. The total kill of Canada geese at Crab Orchard is relatively small compared to the harvest adjacent to other southern Illinois refuge areas. Approximately 2,200 geese were killed each season in the vicinity of Crab Orchard out of average populations of 39,000 and 36,000 geese during the 1963 and 1964 hunting seasons, respectively. It is unlikely that a significant number of the tagged geese were survivors of unknown groups in which relationships may have been altered by hunting. I conclude that the data presented should reflect the relative importance of various yearling associations encountered in a winter flock of Canada geese.

IMPLICATIONS

Especially basic to further understanding of a variety of topics in the biology of a gregarious species is knowledge of social structure. For example, movement patterns, species-specific and obviously learned behaviors, and indeed the concepts of evolution of Canada geese are not to be understood without knowledge of social relationships. In turn, insight into goose society and behavior depends upon knowledge of the triumph ceremony (Fischer 1965).

Confusion and conflicting opinions are widespread with regard to families of geese

in winter and virtually nothing was known of yearlings in winter. The results of this study in concert with data provided by other investigations document generalizations on the unity of families and the role of yearlings in the flock.

Family relationships influence sampling procedures used for management purposes, for example, trapping (Raveling 1966). The fact that yearlings may associate with families or exist in sibling or other groups compounds the difficulty of utilizing group counts for assessing reproductive success as is done more easily for other goose species with readily identifiable age-classes based on plumage development (Lynch and Singleton 1964). However, because families do remain together almost constantly and most yearlings are singles, there does exist hope that family counts may be the most economical and accurate method possible to assess production of some flocks.

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